422 Rec'd PCT/PTO 05 MAY 2000

FORM PTO-1390 (REV. 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 11150/8
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/530936

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP98/06966	4 November 1998 (04.11.98)	7 November 1997 (07.11.97)

TITLE OF INVENTION
METHOD AND DEVICE FOR MONITORING AND/OR DETERMINING MOTOR OIL QUALITY

APPLICANT(S) FOR DO/EO/US
PICKERT, Detlef; SCHUMACHER, Volker; SÖLTER, Harald; VÖLTZ, Martin

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (unsigned)
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
    ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Preliminary Examination Report and International Search Report.

EXPRESS NO: EL179949826US

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U.S. APPLICATION NO if known, see 37 C.F.R. 1.5 09/530936	INTERNATIONAL APPLICATION NO PCT/EP98/06966	ATTORNEY'S DOCKET NUMBER 11150/8

17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):
Search Report has been prepared by the EPO or JPO $840.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) .. $670.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $760.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $970.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $96.00

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$840.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	60-20 =	40	X $18.00	$720.00	
Independent Claims	3-- 3 =	0	X $78.00	$	
Multiple dependent claim(s) (if applicable)			+ $260.00	$	
TOTAL OF ABOVE CALCULATIONS =				$	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$1,560.00	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$1,560.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$1,560.00	
				Amount to be. refunded	$
				charged	$

a. ☐ A check in the amount of $__________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$1,560.00** to cover the above fees. A duplicate copy of this sheet is enclosed

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE:

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Richard L. Mayer
By: Mary C. Weiser Reg. No. 30,333
SIGNATURE

Richard L. Mayer
NAME

22,490
REGISTRATION NUMBER

May 5, 2000
DATE

09/530936
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: PICKERT et al.

SERIAL NO.: to be assigned

FILED: herewith

TITLE: METHOD AND DEVICE FOR MONITORING AND/OR DETERMINING MOTOR OIL QUALITY

ART UNIT: not yet known

EXAMINER: not yet known

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

PRELIMINARY AMENDMENT

Please amend the above-identified application before a first consideration on the merits as follows:

IN THE SPECIFICATION

On page 1, before line 2, insert --Field of the Invention--.

On page 1, line 2, change "of" to --and device for--.

On page 1, line 4, delete "Furthermore, the invention concerns a device for carrying out the method.

On page 1, before line 6, insert --Background of the Invention--.

On page 1, line 6, change "A plurality of" to --Many--.

On page 1, line 9, change "since otherwise the" to --to avoid--

On page 1, line 10, delete "might be" and change "damaged" to --damage--.

On page 1, line 21, change "With the method according to the definition of the species," to --Known methods for directly determining--.

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On page 1, line 22, before "contamination" insert --degradation or-- and change "can be determined directly" to --include-- and change "as a function of" to --measuring--.

On page 1, line 23, after "resistance" insert --of the oil--.

On page 2, before line 27, insert --<u>Objects and Summary of the Invention</u>--.

On page 2, line 27, change "The" to --An-- and change "allowing" to --and device that provide for--.

On page 2, lines 29 to 30, delete "Furthermore, the object is to provide a device for carrying out the method."

On page 3, lines 1 to 2, delete "This object is achieved through the features of Claims 1, 7, and 15. Preferred embodiments of the invention are the objects of the subclaims."

On page 3, line 7, after "manner" insert --as a function of the engines temperature and frictional torque--.

On page 3, line 28 to 29, delete "according to Claim 7 using a method of".

On page 3, line 29, before "determining" insert --by-- and before "viscosity" insert --quality, particularly the-- and after "viscosity" insert --,--.

On page 3, line 29 to 30, change ", in particular, according to Claim 1" to --as a function of engine temperature and frictional torque--.

On page 4, line 1, before "time" insert --proper--.

On page 4, line 3, change "are" to --may be--.

On page 4, line 4, before "injection" insert --i)--.

On page 4, line 5, before "a clutch" insert --ii)--.

On page 4, line 6, before "the load" insert --iii)--.

On page 4, line 7, before "signals" insert --iv)--.

On page 4, line 9, change "ensured" to --provided--.

On page 4, line 11, before "data" insert --engine-- and change "are" to --may be-- and after "torque:" insert --i)--.

On page 4, line 13, before "the generator" insert --ii)--.

On page 4, line 14, before "the engine rpm" insert --iii)-- and after "and" insert --iv)--.

On page 4, line 17, change "is furthermore achieved" to --can also be realized--.

On page 4, line 19, before "to the moment" insert --at the engine--.

On page 4, line 21, change "estimated" to --derived-- and after "time" change "," to --and--.

On page 4, line 22, change "determined" to --estimated therefrom--.

On page 4, line 24, change "is furthermore achieved" to --can also be realized--.

On page 4, line 27, after "curves" insert --,--.

On page 4, line 31, delete "Further embodiments of the invention are presented in the subclaims and the".

On page 5, before line 1, insert --<u>Brief Description of the Drawings</u>--.

On page 5, line 1, delete "description."

On page 5, line 4, after "engine" change "," to --;--.

On page 5, before line 8, insert --<u>Detailed Description of the Invention</u>--.

On page 7, line 17, change "i.e." to --*i.e.*--.

On page 8, line 26, change "The engine" to --An engine--.

On page 8, line 31, change "loss torque" to --torque loss-- and change "i.e." to --*i.e.*--.

On page 10, delete all lines.

<u>IN THE CLAIMS</u>

Please cancel without prejudice claims 1-16 and insert new claims 17-38.

17. A method for determining motor oil quality during operation of an internal combustion engine comprising the step of:
determining the oil quality as a function of temperature and frictional torque of the engine.

18. A method for determining motor oil quality by determining the viscosity of the motor oil during operation of an internal combustion engine comprising the step of:
determining the oil viscosity as a function of the temperature and the frictional torque of the engine.

19. The method according to Claim 18, wherein:
the engine includes a starter motor and the frictional torque of the engine is derived from the starter motor torque.

20. The method according to Claim 18 or 19, wherein:
the frictional torque of the engines derived from a measurement of electric power consumed by the starter during starting and a known starter power consumption characteristic curve.

21. The method according to Claim 19, wherein:
the frictional torque of the engine is derived from a measurement of power consumption during engine acceleration.

22. The method according to Claim 18, wherein:
the reversible temperature effect is taken into account.

23. The method according to Claim 18, wherein a change in viscosity is only taken into account if the value (actual value) is outside a range of -15% to +50% of a predefined viscosity value at the same temperature.

24. A method of determining the viscosity of the motor oil in an internal combustion engine, comprising the step of:
determining the viscosity of the motor oil from the engine frictional torque.

25. The method according to Claim 24, wherein:
the viscosity of the motor oil is derived from an estimate of the engine frictional torque.

26. The method according to one of Claims 24 or 25, wherein:
the engine frictional torque is determined from the engine data available in an engine controller.

27. The method according to Claim 26, wherein:
one or more engine data selected from the group consisting of: injection time; throttle valve position; a signal that indicates whether a torque is transmitted to the drive train; and, signals concerning the operating condition of any auxiliary units directly driven by the engine; is used to determine the engine frictional torque.

28. The method according to Claim 26, wherein:
the engine a diesel engine and at least one engine data selected from the group consisting of: a signal that indicates whether a torque is transmitted to the drive train; the load signal of the generator as a measure of the electric power generated by the generator; the engine rpm; the injected amount of fuel; the engine temperature; and; the ambient temperature; is used to determine the engine frictional torque.

29. The method according to one of Claims 24, 25 and 27, wherein:
the frictional torque of the engine is derived from the determination of the start torque and the engine acceleration power consumed.

30. The method according to Claim 29, wherein:
the engine is a gasoline engine.

31. The method according to Claim 29, wherein:
the starter torque is determined from the electric power consumed by the starter based on a known starter characteristic.

32. The method of determining the viscosity of motor oil of an internal combustion engine according to Claim 29, further comprising the steps of:
measuring the time between a start until a predetermined starter disengagement speed is reached, injecting a predetermined amount of fuel amount during the

measured time, and estimating the frictional torque of the engine from the measured time.

33. A device for carrying out the method according to Claim 17, 18, 19, 21, 22, 23, 24, 25 or 26, wherein:
the device has a controller for processing and transforming measured data and at least one memory unit, characteristic curves needed for determining the viscosity being stored in the memory unit or in each memory unit.

34. A device for carrying out the method according to one of Claim 20, wherein:
the device has a controller for processing and transforming measured data and at least one memory unit, characteristic curves needed for determining the viscosity being stored in the memory unit or in each memory unit.

35. A device for carrying out the method according to one of Claim 24 or 25, wherein:
the device has a controller for processing and transforming measured data and at least one memory unit, characteristic curves needed for determining the viscosity being stored in the memory unit or in each memory unit.

36. The device according to Claim 33, wherein:
the characteristic curves are stored in the form of lookup tables.

37. The device according to Claim 34, wherein:
the characteristic curves are stored in the form of lookup tables.

38. The device according to Claim 35, wherein:
the characteristic curves are stored in the form of lookup tables.

IN THE ABSTRACT

Please insert attached page titled "ABSTRACT OF DISCLOSURE".

REMARKS

This Preliminary Amendment cancels original claims 1-16 in the underlying PCT Application No. PCT/EP98/06966 and adds new claims 17-38. The new claims do not add new matter to the application but do conform the claims to U.S. Patent and Trademark Office rules.

The amendments to the specification and abstract are to conform the specification and abstract to U.S. Patent and Trademark Office rules. It is respectfully submitted that the amendments to the specification and abstract do not introduce new matter into the application.

The underlying PCT application includes a Search Report, a copy of which is included herewith.

Conclusion

Consideration of the present application as amended is hereby respectfully requested.

Respectfully Submitted,

Kenyon & Kenyon

Richard L. Mayer

Dated: 5/5/00 By: Mary C. Werner Reg. No. 30,333

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2/PART

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METHOD AND DEVICE FOR MONITORING AND/OR DETERMINING MOTOR OIL QUALITY

The invention relates to a method of monitoring and/or determining motor oil quality by determining the viscosity of the motor oil being used by internal combustion engines. Furthermore, the invention concerns a device for carrying out the method.

A plurality of known devices such as machine tools and motor vehicles must be serviced in certain intervals in order to ensure their reliability and extend their service life. The motor oil used by the engine of a motor vehicle is subject to degradation and must be changed after reaching a certain degree of degradation, since otherwise the engine might be damaged due to insufficient lubrication and cooling. The service life of a motor oil depends, however, on many operating parameters, such as environmental conditions and the driver's driving style. Since these are not predictable, certain safety margins are used and the manufacturer specifies fixed service intervals and oil change intervals for the sake of simplicity, expressed, for example, as fixed mileage figures, and which must be observed for the manufacturer's warranty to remain valid. This results in the vehicle owner often having the vehicle serviced or the oil changed without any valid technical reason, which represents a considerable additional cost factor. Therefore, considerable efforts have been made for some time to match the oil change intervals to the actual degradation of the motor oil.

With the method according to the definition of the species, the degree of motor oil contamination can be determined directly, for example, as a function of the electrical resistance, the pressure differential between upstream and downstream sides of the oil filter, transparency, or chemical composition of the motor oil. The disadvantage of these direct methods is the additional cost of measuring, for example, the need for additional and special sensors, etc. Therefore, in addition to direct measuring methods, there are methods in which the degree of degradation of the motor oil is determined from operating parameters of the engine or the vehicle that are known otherwise.

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European Patent 174 601 discloses a warning system that measures and displays the degradation or aging of the oil in an internal combustion engine and emits a warning signal. The condition of the oil is evaluated and the result of the evaluation is output based on engine parameters such as rotation speed, instantaneous engine load, and oil temperature.

German Patent 41 31 969 presents a lubricating oil monitoring system, in which the oil parameters such as pressure, temperature, and viscosity are measured using a special sensor chip and the actual condition of the motor oil is derived from these parameters. The viscosity of the motor oil is determined using capacitive measurement of the dielectric constant of the oil at two different frequencies. As an alternative, the viscosity of the motor oil can also be determined by measuring sound wave dampening in the motor oil.

German Patent 32 28 195 discloses a method and a device for monitoring the time for a lubricating oil change in a vehicle engine. One essential step of this method is the determination of the contaminant level in the motor oil, which can be derived from the operating conditions of the engine, the level of contaminants being in direct relationship to the viscosity of the motor oil.

The disadvantage of the known methods is that either additional sensors are needed or the conclusion regarding the degree of degradation of the motor oil from known operating parameters does not have the required accuracy and therefore, for safety reasons, the motor oil is changed too early, resulting in extra cost to the owner of the vehicle.

The object of the present invention is therefore to develop a method allowing the motor oil quality of a motor vehicle engine to be monitored and/or determined in a simple and accurate manner. Furthermore, the object is to provide a device for carrying out the method.

This object is achieved through the features of Claims 1, 7, and 15. Preferred embodiments of the invention are the objects of the subclaims.

This object is achieved by determining and evaluating changes in oil viscosity as a function of temperature and engine frictional torque. The method according to the present invention allows changes in motor oil viscosity, which in turn are used for monitoring the motor oil quality, to be determined in a reliable manner. If the motor oil quality is known, an oil change is not required until the motor oil has actually degraded.

In a preferred embodiment of the method the engine frictional torque is derived from the starting torque. This allows the engine frictional torque to be determined in a simple manner.

In another advantageous embodiment of the present invention, the starting torque is determined from the electric power consumed by the starter during start, with the starter characteristics being known. This method is particularly simple, since current consumption essentially corresponds to the battery load and is therefore easy to determine. Current consumption as a function of motor oil quality is therefore simple to use for determining or evaluating quality.

Advantageously, changes in viscosity are not taken into account unless the value (actual value) is outside a range of -15% to +50% of a predefined viscosity value at the same temperature. This prevents slight variations in viscosity due to different marginal parameters resulting in an “oil change needed” display. It is ensured that only significant changes are taken into account in monitoring and subsequent action is not taken before the right time.

The object of the present invention is furthermore achieved according to Claim 7 using a method of determining motor oil viscosity in an internal combustion engine, in particular, according to Claim 1. By determining the viscosity of the motor oil from the engine frictional torque, with the latter being determined from data present in an engine

controller, the time for oil change is determined in a simple manner.

In the case of a gasoline engine, the following engine data are advantageously used for determining the engine frictional torque: injection time and/or throttle valve position to determine the engine torque produced; a clutch switch signal, showing whether torque is being transmitted to the drive train; the load signal of the generator to determine the generator drive torque; and signals concerning the operating state of any other auxiliary devices directly driven by the engine. Thus, reliable determination of the motor oil quality is ensured.

In a diesel engine, the following data are used for determining the frictional torque: a clutch switch signal, which shows whether torque is being transmitted to the drive train; the generator load signal as a measure of the electric power generated by the generator; the engine rpm; the injected amount of fuel; the engine temperature; and the ambient temperature. This allows the engine oil quality to be reliably determined.

The object of the present invention is furthermore achieved using a method of determining the motor oil viscosity in an internal combustion engine. By measuring the time from start to the moment when the starter disengagement speed is reached, so that if the constant fuel amount injected during this time is known, the engine frictional torque can be estimated from the measured time, the motor oil quality can be reliably and accurately determined.

The object of the present invention is furthermore achieved using a device for carrying out the method. In order to determine viscosity, this device has a control unit for processing and transforming data and at least one memory, with the characteristic curves needed for determining the viscosity being stored in the memory or in each memory. Such a device allows the motor oil quality to be determined in a simple manner, since no additional measuring means are needed.

Further embodiments of the invention are presented in the subclaims and the

description. Preferred embodiments are explained in detail below with reference to the drawings.

Figure 1 shows a diagram for determining the oil viscosity in a diesel engine, and

Figure 2 shows a diagram for determining the viscosity from the electric power consumption of a starter.

The calculation method illustrated in Figure 1 is based on the torque equilibrium of the engine that is not in gear and is idling. In this mode of operation, most quantities are constant, so that their effect on the engine torque generated can be stored in characteristic maps, preferably in the form of lookup tables.

The stationary torque equilibrium of an engine can be written as

$$M_{engine} = M_{clutch} + M_{aux.devices} + M_{friction} + M_{compression} \qquad (1)$$

where $M_{aux.devices} = M_{water\ pump} + M_{oil\ pump} + M_{generator}$ (2)

if no other auxiliary devices are connected.

Under idling conditions, i.e., not in gear, the following equations apply:

$$M_{clutch} = 0 \text{ (any load is disengaged)} \qquad (3)$$

$$N_{engine} = \text{constant} \Rightarrow dN/dt = 0 \text{ (idling speed is controlled)} \qquad (4)$$

$$M_{water\ pump} = \text{constant} \qquad (5)$$

$$M_{generator} = f(P_{electric}) \qquad (6)$$

(generator torque is a function of electric power)

$$M_{compression} = f(T_{engine}, T_{ambient}) \tag{7}$$

(engine compression torque is a function of engine temperature and ambient temperature)

$$M_{friction} + M_{oil\ pump} = f(v_{oil}, T_{engine}, T_{ambient}), \text{ and} \tag{8}$$

$$M_{engine\ idling} = f(v_{oil}, T_{engine}, T_{ambient}) + M_{generator} = f(m_E) \tag{9}$$

(engine torque when idling is a function of the amount of fuel injected).

Therefrom the viscosity is determined assuming the validity of the above equations (3) to (9) during idling:

$$v_{oil} = f(M_{engine\ idling} - M_{generator}, T_{engine}) \tag{10}$$

At a reference temperature T_0 of the oil, which may be 40°C or 100°C, for example, we obtain:

$$v_{oil\ T0} = f(v_{oil}, T_{oil}/T_0) \tag{11}$$

The following definitions apply:

M = torque; N = rpm; T = temperature; P = power,
m_E = injected amount; v = viscosity.

The indices used are self-explanatory.

Figure 1 shows the diagram for this calculation using the example of a diesel engine. Generator signal 1, which is a measure of the electric power $P_{electric}$ generated by the generator, the injected amount m_E 2, engine temperature T_{engine} 3, ambient temperature $T_{ambient}$ 4, and oil temperature T_{oil} 5, as well as clutch signal 6, which shows whether or not the clutch is engaged, and engine rpm N 7 are available. Generator signal 1 is

recalculated into the respective generator torque 10 via a first characteristic map stored in first characteristic map unit 8. In the same manner, injected amount 2 is recalculated into the engine idling torque $M_{engine\ idling}$ 11 via a second characteristic map stored in a second characteristic map unit 9. Forming the difference between the two torques 10 and 11 thus obtained in subtractor 12, the desired frictional torque of equation (9) is obtained, which is a function of oil viscosity. Oil viscosity 14 at the reference temperature is calculated according to equations (10) and (11) via a third characteristic map stored in a third characteristic map unit 13, taking into account engine temperature 3, ambient temperature 4, and oil temperature 5. Characteristic curves or characteristic maps stored in characteristic curve units 8, 9, and 13 are engine-specific and are determined empirically. Since the engine rpm is kept constant by the idling controller, it does not have to be taken into consideration in the non-linear characteristic curve functions in characteristic map units 8, 9, 13. The time derivative of engine rpm 7 is calculated in differentiator 15. The engine rpm differential is ANDed with clutch signal 6 in AND gate 16 to form operating point signal 17. In another logic gate or operating point gate 18, operating point signal 17 of AND gate 16 determines whether or not the determined normalized oil viscosity 14 is valid, i.e., whether the boundary conditions (3) and (4) of equations (10) and (11) are met.

The method illustrated in Figure 2 for determining oil viscosity is based on the evaluation of the energy equilibrium of the start sequence. Since all loads are basically turned off here and the generator delivers almost no electric power in this rpm range, the generator torque can be assumed, in a first approximation, to be the same for each start, as can the load torques caused by the other auxiliary devices (with the exception of the oil pump), assuming the same ambient conditions. The engine frictional torque and the compression energy can also be assumed to be functions of the engine temperature and time. Since the engine frictional torque and, in particular, the drive torque of the oil pump furthermore depends basically on the motor oil viscosity, the latter can be determined from the differences between the starter power and the known reference conditions during a start sequence.

Figure 2 shows a starter 20, which is powered via leads 21 and 22 during start. The respective current and voltage are determined by appropriate instruments A and V. A computing unit 23 calculates the starter power according to

$$P_{starter} = \eta_{starter} * I * U \qquad (12)$$

The starter torque generated by starter 20 is applied to an engine 24. The acceleration power of engine 24 is determined by another computing unit 26 from the engine rpm 25 generated according to

$$P_{accel.} = N * \Theta * dN/dt \qquad (13)$$

Difference ΔP between starter power and acceleration power, determined in subtractor 27, is the desired friction power of the engine, which corresponds to a frictional torque. Oil viscosity 30 is determined from the frictional torque in a characteristic map unit 28, taking into account engine temperature 29 using the equation

$$v_{oil} = f(\Delta P, T_{engine}). \qquad (14)$$

The notations used are defined as follows:

P = power; η = efficiency; I = current; U = voltage;
N = rpm; Θ = moment of inertia; ΔP = friction power.

In a third embodiment (not illustrated), the time from start to the moment when the starter disengagement rpm is reached is measured during the start sequence. The engine controller injects a fixed amount of fuel during start, until the starter disengagement rpm is reached. Then the controller switches over to regular idling control. The exact moment of switch-over depends on the torque equilibrium of the engine in the start phase. Since the variation in the torque generated results from the injected fuel amount and is known, the loss torque, i.e., the engine frictional torque, can be estimated from the time elapsed

until the starter disengagement speed is reached. The viscosity of the motor oil can thus be estimated from the additional load using reference tests. The "engine regular mode status bit" signal from the engine controller can be used for this measurement. This bit is "0" in the start phase and is set to "1" when the starter disengagement speed is reached. The starter disengagement speed is usually about 1200 rpm.

Reference symbol list

1	generator load signal
2	injected amount
3	engine temperature
4	ambient temperature
5	oil temperature
6	clutch signal
7	engine rpm
8	first characteristic curve unit
9	second characteristic curve unit
10	generator torque
11	engine idling torque
12	subtractor
13	third characteristic curve unit
14	oil viscosity
15	differentiator
16	AND gate
17	operating point signal
18	operating point gate
20	starter
21	lead
22	lead
23	computing unit
24	engine
25	engine rpm
26	computing unit
27	subtractor
28	characteristic curve unit
29	engine temperature
30	oil viscosity

Patent Claims

1. A method of monitoring and/or determining motor oil quality by determining the viscosity of the motor oil during the operation of an internal combustion engine, in particular a motor vehicle engine,
characterized in that changes in the oil viscosity are determined and evaluated as a function of the temperature and the frictional torque of the engine.

2. The method according to Claim 1,
characterized in that the frictional torque of the engine is determined from the starter torque that has been determined.

3. The method according to Claim 1 or 2,
characterized in that the starter torque is determined from the electric power consumed by the starter during start, the starter characteristic curve being known.

4. The method according to Claim 2,
characterized in that the frictional torque of the engine is derived from the engine acceleration power consumed.

5. The method according to Claim 1,
characterized in that the reversible temperature effect is taken into account.

6. The method according to Claim 1,
characterized in that a change in viscosity is only taken into account if the value (actual value) is outside a range of -15% to +50% of a predefined viscosity value at the same temperature.

7. A method of determining the viscosity of the motor oil of an internal combustion engine,
characterized in that the viscosity of the motor oil is determined from the engine frictional torque.

8. The method according to Claim 7,
characterized in that the viscosity of the motor oil is derived from an estimate of the engine frictional torque.

9. The method according to one of Claims 7 to 8, characterized in that the engine frictional torque is determined from the engine data available in the engine controller.

10. The method according to Claim 9,
characterized in that the following engine data are used for determining the engine frictional torque:
- injection time and/or throttle valve position to determine the engine torque generated;
- a signal that indicates whether a torque is transmitted to the drive train;
- and signals concerning the operating condition of any other auxiliary units directly driven by the engine.

11. The method according to Claim 9,
characterized in that in a diesel engine the following engine data are used for determining the engine frictional torque:
- a signal that indicates whether a torque is transmitted to the drive train;
- the load signal of the generator as a measure of the electric power generated by the generator;
- the engine rpm;
- the injected amount of fuel;
- the engine temperature, and
- the ambient temperature.

12. The method according to one of Claims 7 through 11, characterized in that the frictional torque of the engine is derived from the determination of the start torque and the engine acceleration power consumed.

13. The method according to Claim 12,
characterized in that the starter torque can be determined from the electric power consumed by the starter, the starter characteristic being known.

14. The method of determining the viscosity of motor oil of an internal combustion engine according to Claim 12, characterized in that during start the time between start until the starter disengagement speed is reached is measured, so that with the constant fuel amount injected during this time being known, the frictional torque of the engine can be estimated from the measured time.

15. A device for carrying out the method according to one of Claims 1 through 14, characterized in that the device has a controller for processing and transforming measured data and at least one memory unit, the characteristic curves needed for determining the viscosity being stored in the memory unit or in each memory unit.

16. The device according to Claim 15,
characterized in that the characteristic curves are stored in the form of lookup tables.

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ABSTRACT OF DISCLOSURE

The present invention provides a method and device for determining the viscosity of motor oil in an internal combustion engine comprising: measuring frictional torque of the engine based on engine data, such as, the clutch switch signal which shows whether the clutch is engaged transmitting torque to the drive train; a generator load signal, a starter load signal, acceleration power consumption, and the like.

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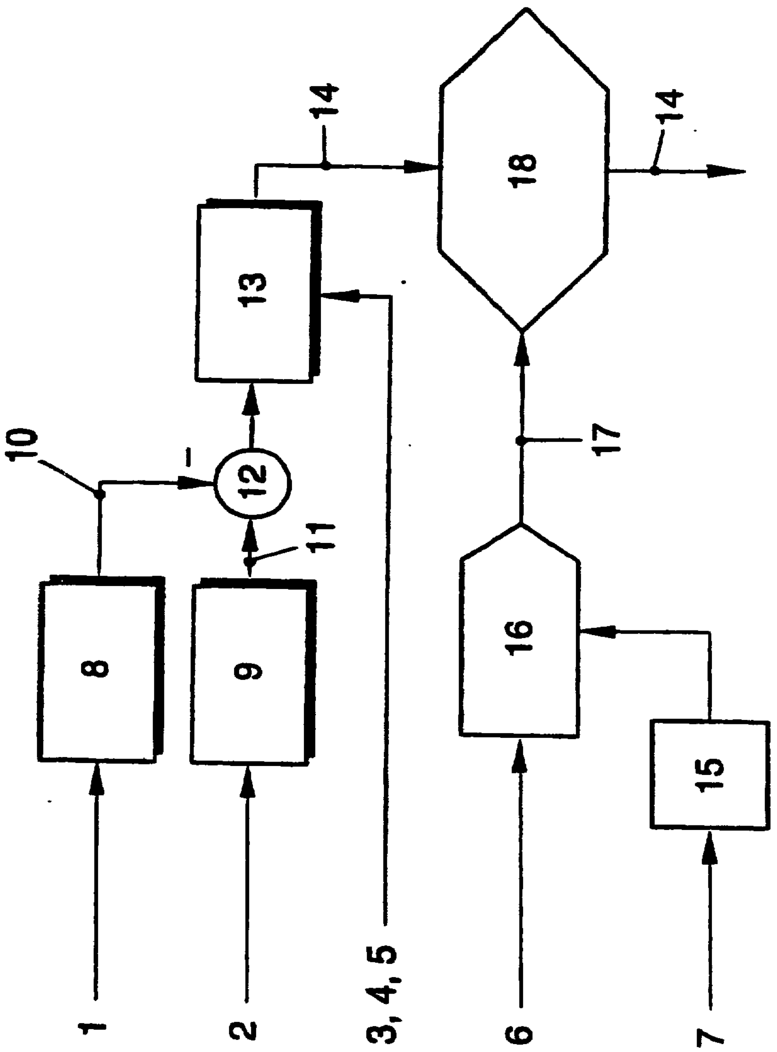

FIG. 1

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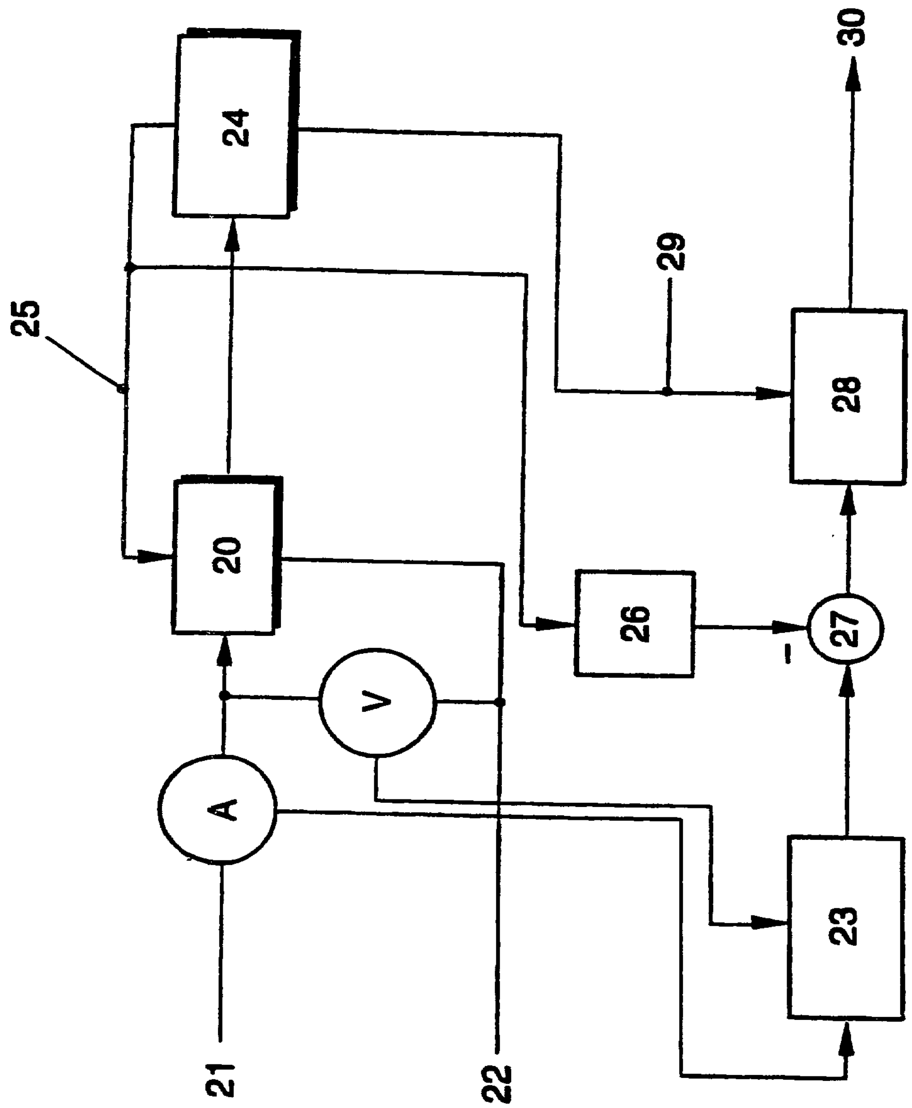

FIG. 2

Rec'd PCT/PTO 18 AUG 2000

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	
DECLARATION AND POWER OF ATTORNEY	ATTORNEY'S DOCKET NO. **11150/8**

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name,

I believe I am an original, first, and joint inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled **METHOD AND DEVICE FOR MONITORING AND/OR DETERMINING MOTOR OIL QUALITY**, the specification of which was filed as International Application No. **PCT/EP98/06966** on **4 November 1998**, and is filed herewith in the United States Patent and Trademark Office.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

PRIOR FOREIGN APPLICATION(S)

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119
GERMANY	**197 49 364.5**	**7 November 1997**		**YES**

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I declare that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

1-00

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